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Zero Touch Provisioning for NETCONF Call Home (ZeroTouch)
draft-ietf-netconf-zerotouch-00

Abstract

This draft presents a technique for establishing a secure NETCONF connection between a newly deployed IP-based device, configured with just its factory default settings, and the new owner's Network Management System (NMS).

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on January 02, 2015.

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1. Introduction

1.1. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

1.2. Objectives

A fundamental business requirement is to reduce operational costs where possible. Deploying new IP-based devices is many times one of the largest costs in running a network, as sending trained specialists to each site to do an installation is both cost prohibitive and does not scale.

Both networking vendors and standard bodies have tried to address this issue, with varying levels of success. For instance, the Broadband Forum TR-069 specification [TR069] relies solely on DHCP for NMS discovery, but this can only work in environments where the DHCP server is locally administered, which is not the case when the device is connected to an ISP's network. In another example, some network vendors have enabled their devices to load an initial configuration from removable storage media (e.g., a USB flash drive), but not all devices have such ports.

The solution presented herein, ZeroTouch, enables a device to securely obtain an initial configuration from the network without any operator intervention. The discovered configuration initiates the device to "call home" using either the SSH or TLS, as described in [NETCONF-REVERSE-SSH] and [RFC5539bis] respectively.

1.3. Use Cases

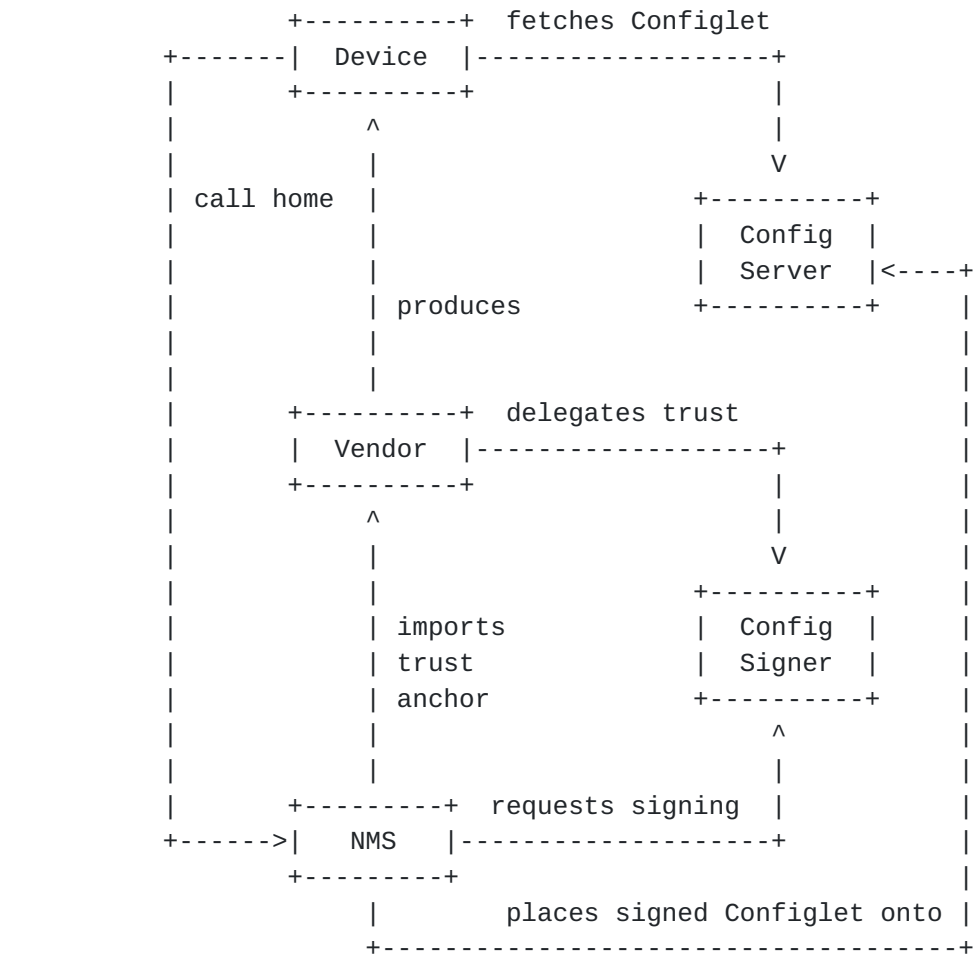
- Connecting to a remotely administered network

  This use-case involves scenarios, such as a remote branch office or convenience store, whereby the device connects to an ISP's network. In this case, the device receives only generic networking settings (address, netmask, gateway, DNS servers, etc.) provided by the ISP, with no site-specific customizations, such that the device has no recourse but to reach out to the presumably insecure network for its initial configuration.

- Connecting to a locally administered network

  This use-case covers all other scenarios and differs only in that the device may additionally receive some site-specific information to guide its call home process, which could then direct it to a local server for its initial configuration. If no site-specific information is provided, or the device is unable to use the information provided, it can then reach out to network just as it would for a remotely administered network.

1.4. Actors and Roles



Though not represented as a box in the diagram, the Configlet is also a first-class object in the solution.

o Configlet

  A Configlet is an XML document that, when loaded onto a device, configures the device to initiate a call home connection to a deployment specific NMS, as well as set a local administrator account for the NMS to log into. The Configlet is signed and optionally encrypted. More information about Configlets is in Section 7.

o Configuration Server

  A Configuration Server hosts configurations to be downloaded over a network. Configuration Servers can be deployed either on the locally administered network or on some external network

(e.g., the Internet). Configuration Servers are known to devices in the form of a URI, which can be either preconfigured or dynamically discovered. More information about Configuration Servers is in Section 2.

- Configuration Signer

  A Configuration Signer is an entity that the device's vendor has delegated the signing function to. A Configuration Signer only needs to ensure that the requestor is the rightful owner of the device to which a configuration is destined. A Configuration Signer may be site-specific or an external entity. More information about Configuration Signers is in Section 3.

- Device

  The device is the networking entity that initiates ZeroTouch, whenever booting with its factory default settings. The device is preconfigured with a secure device identity, for Configuration Servers URIs, and certificates for Configuration Signers and Configuration Servers it trusts by default. A device may dynamically discover additional URIs and certificates from a locally-administered network. More information about Devices is in Section 4.

- Network Management System

  The NMS is the deployment-specific system that devices initiate their call home connections to. The NMS must be configured with vendor-specific trust anchors and unique device identifiers. The administrators of the NMS system interact with Configuration Signer and Configuration Server systems to stage the the device configurations. More information about Network Management Systems is in Section 5.

- Vendor

  Vendors manufacture the devices with secure device identities and preconfigured Configuration URIs, and Configuration Signer certificates. Vendors are the de facto Configuration Signer for the devices it manufactures, but may delegate that role to external Configuration Signers. More information about Vendors is in Section 6.

2. Configuration Server

A Configuration Server is the entity hosting configurations that can be downloaded over a network. This section describes the service interface a Configuration Server must implement as well as what's needed for transport security.

2.1. Service Interface

Configuration Servers are known to devices in the form of a URI. Configuration Servers MUST support the URI schemes "https" and "http". Other URI schemes are not supported.

When accessing a Configuration Server, the device appends its unique device identifier (UID) to the URI. The unique identifies MUST be the same as the identifier stored within the device's IDevID certificate.

For instance, if the URI were:

```
http://example.com/zerotouch/devices/
https://example.com/zerotouch?id=
```

then the device would try to access:

```
http://example.com/zerotouch/devices/<uid>
https://example.com/zerotouch?id=<uid>
```

When accessing the Configuration Server, the HTTP Accept-Type MUST be set to either "application/zerotouch-config" or "application/zerotouch-bootimage". Please see Section 9.2. A wildcard Accept-Type (e.g., */*) SHOULD default to "application/zerotouch-config".

2.2. Interactive Interface

The Configuration server SHOULD to provide some user-facing interface to enable to the end-user to provide a Configlet and, optionally, an bootimage file. How the Configlet and bootimage file are provided to the Configuration Server is outside the scope of this document.

2.3. Transport Security

As described in Section 3, configurations MUST be signed and MAY be encrypted. As such, transport-level security is not needed to assure authenticity or confidentiality of the configuration itself. However, transport-level security enables devices to authenticate the Configuration Server and also extends confidentiality to the application-level protocol. Therefore, it is RECOMMENDED for Configuration Servers to support transport-level encryption.

If a Configuration Server uses X.509-based encryption, then its X.509 certificate MUST have a chain of trust to a trust anchor known to devices (see Section 4.2. More specifically, the Configuration Server MUST possess all the intermediate certificates leading to the trust anchor.

When a Configuration Server negotiates encryption with the device, it provides the chain of certificates, from its own to, but not including, the trust anchor. Including the trust anchor's certificate is unnecessary since the device MUST be pre-provisioned with it. Devices need the chain of certificates to be passed so they can validate the server using only a list of Configuration Server trust anchors.

2.4. Expiration Policy

An expiration policy is needed to limit how long a Configuration Server needs to retain a configuration and, in turn, how many configurations it might need to retain at a given time.

It is expected that Configuration Servers will enable retention information to be given at the same time as when the configuration is provided to it. Options should be temporal in nature, not based on access counts, so as to thwart a DoS attack whereby the configuration is accessed by an entity other than the device. Configuration Servers SHOULD put a limit on the maximum amount of time it will hold onto a configuration before purging it, even if the configuration had never been accessed.

2.5. Troubleshooting and Auditing

In order to facilitate troubleshooting and auditing, the Configuration Server SHOULD record into a log a record of the various Configlet download requests. This draft does not define what information should be kept or for how long.

3. Configuration Signer

3.1. Overview

A Configuration Signer MUST be able to sign configurations. This function requires the Configuration Signer be able to authenticate that the requestor is the true owner of the device, as identified within the contents of the configuration being signed.

The user interface a Configuration Signer provides to perform its role is outside the scope of this document. However, in order to meet operational expectations, the time it takes to respond to a request should be as expeditious as possible.

A Configuration Signer does not need to retain a configuration after signing it. The Configuration Signer SHOULD retain an audit log for indemnification purposes.

3.2. Signing Configurations

A Configlet Signer MUST have an X.509 certificate with Key Usage capable of signing data (digitalSignature) and be signed by a certificate authority having a chain of trust leading to a trust anchor known to the devices loading its Configlets. The Configlet Signer MUST possess all intermediate certificates leading to its trust anchor.

When a Configlet Signer signs a Configlet, it attaches both the signature and the chain of X.509 certificates, including its own, but not necessarily including the trust anchor's certificate. This chain of certificates is needed so a device can validate a Configlet using only the Configlet Signer trust anchors known to it.

3.3. Optional Encryption

A Configuration Signer MAY optionally encrypt configurations prior to signing them. This function requires the Configuration Signer know the device's unique public key, as encoded within its secure device identity certificate.

3.4. Delegation of Trust

A device's vendor is the root of trust for all of its devices. That is, the vendor's devices implicitly trust the vendor for such things as software images, subscription updates, and licenses. As such, the vendor is the ultimate Configuration Signer for its devices.

However, both vendors and its customers may prefer a this role be performed by another entity. For instance, a vendor may not want this role due to it being outside its primary business function, and customers may not want the vendor to have this role for privacy reasons.

It is therefore provided that a vendor MAY delegate the Configuration Signer role to other entities. Using X.509 certificates, the Vendor need only sign the delegate's certificate signing request (CSR), providing back to the delegate a signed X.509 certificate authenticating its ability to perform the signing function.

In order enable a delegate to fulfill its operational role, as described in Section 3.1, the vendor MUST provide a mechanism that can be used to authenticate if a given requestor is the true owner of a specific device. Additionally, to support Configuration Signers that want to encrypt configurations, the vendor MUST also provide a means for the Configuration Signer to know the public key for a given device. How the vendor provides this information to Configuration Signers is outside the scope of this document.

3.5. Delegation to a Specific Customer

The general expectation is that the Configuration Signer is an impartial 3rd-party. However, certain deployments may want to be able to perform the function for themselves. Yet without constraints, that deployment could sign configurations for devices that do not belong to it.

Resolving this concern is possible when 1) the deployment specific Configuration Signer's certificate is annotated with a customer identifier and 2) the devices sold to that customer have that same identifier encoded into their secure device identifier.

This entails the vendor augmenting its manufacturing process for these special devices, which would likely be sold directly to the customer, as opposed to through a sales channel. This takes extraordinary effort and likely only implemented for the most important customers, if at all.

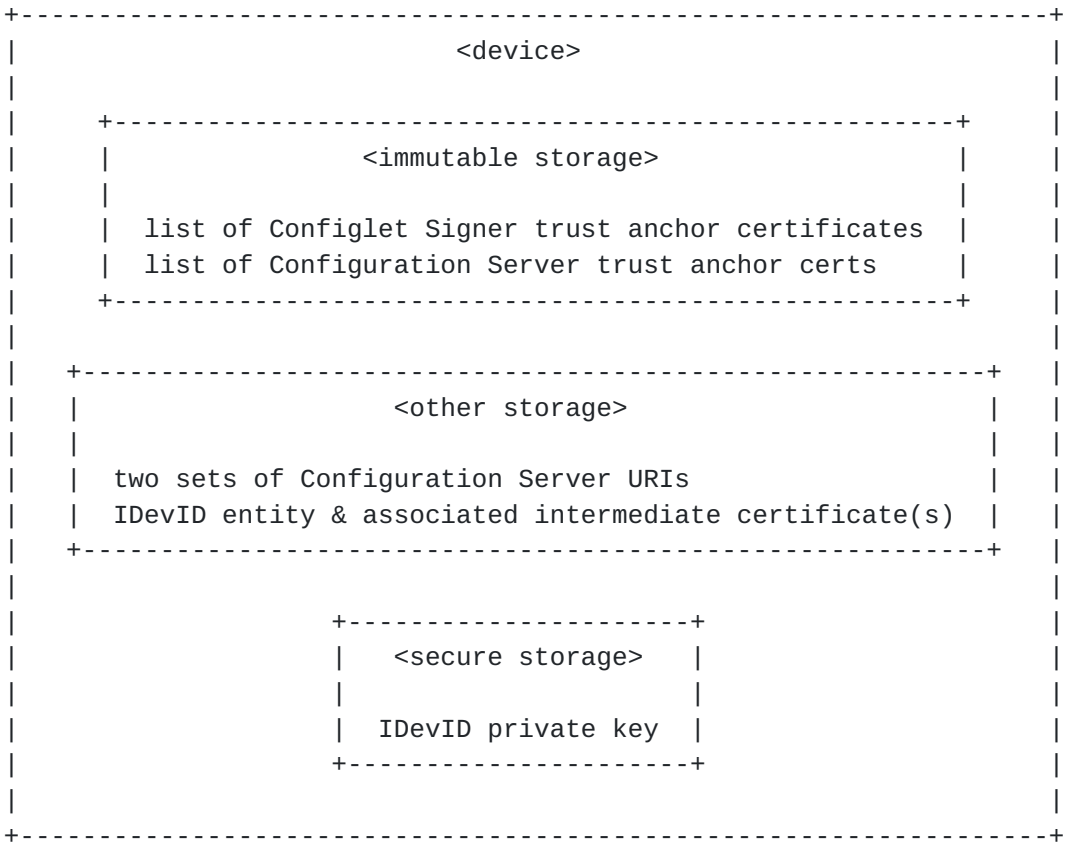
4. Device

4.1. Overview

While the wholistic solution, ZeroTouch, involves a number of entities, a device being powered-on is the essential event that sets things in motion.

Whenever a device boots with its factory default settings, it initiates ZeroTouch with the goal of finding a configuration to initialize itself with. Once a configuration is found, the device initializes its running datastore with it and then enters normal operation. Since the configuration initializes the device to call home upon entering its normal operating mode, the device immediately begins trying to establish a secure connection with the deployment specific NMS.

4.2. Factory Default State



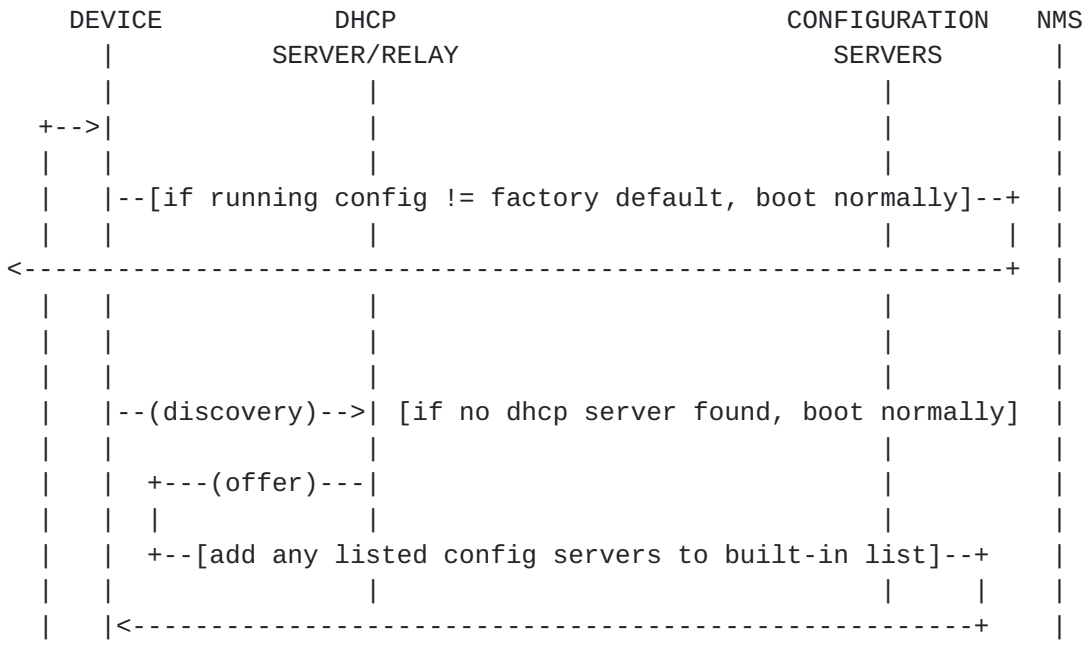
Devices supporting ZeroTouch MUST have a manufacturer-provisioned secure device identifier, as defined in [Std-802.1AR-2009]. This identifier is known by the IEEE standard as the Initial Device Identifier (IDevID). The IDevID includes both an X.509 certificate, encoding a globally unique per-device identifier, and a chain of X.509 certificates leading to the manufacturer's well-known trust anchor. The IDevID is needed in order for the NMS to positively authenticate a device. For NETCONF over SSH Call Home ([NETCONF-REVERSE-SSH]), this certificate requirement constrains the SSH host key algorithms the device is allowed to advertise to those defined in [RFC6187].

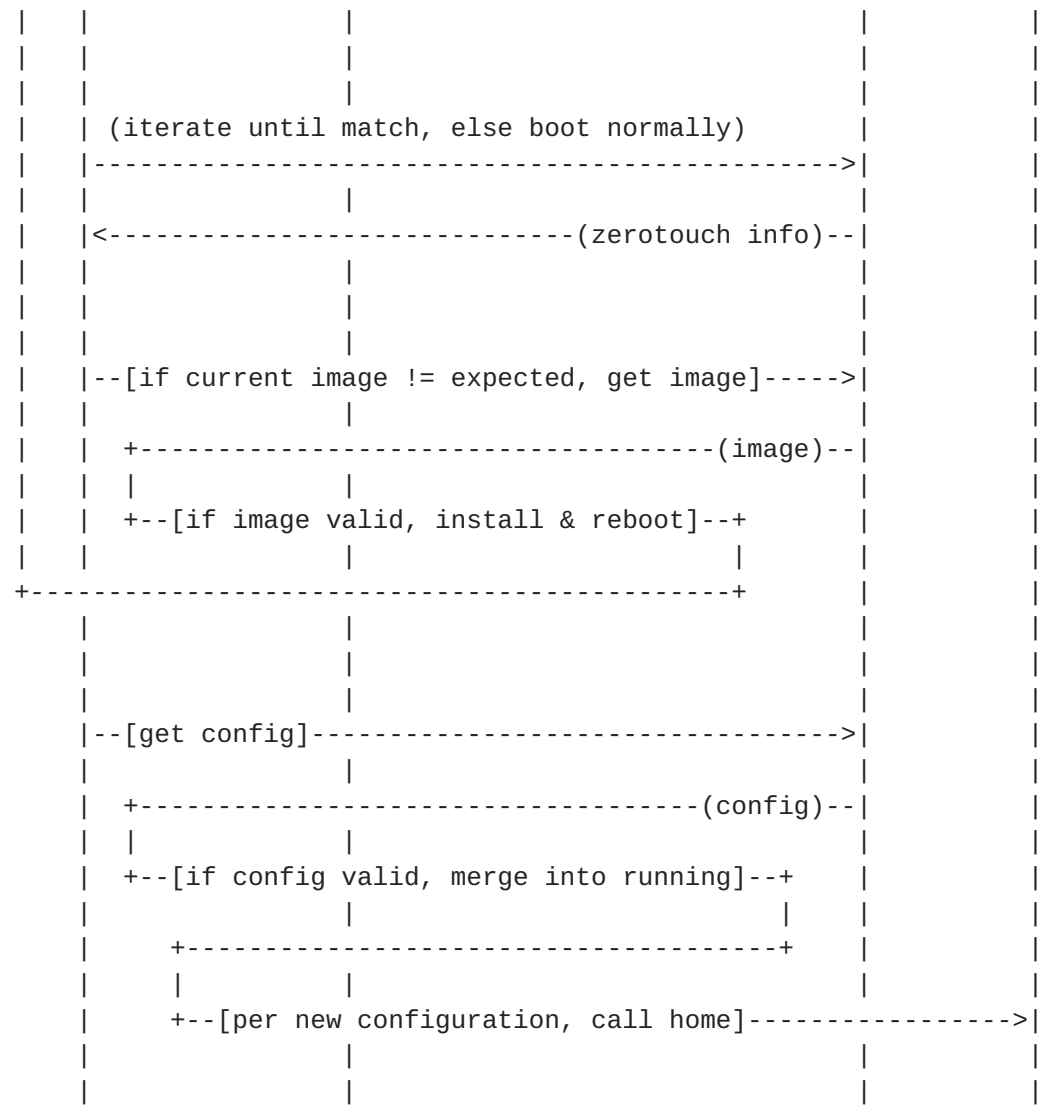
Devices supporting ZeroTouch MUST be pre-provisioned with one or more URIs for Internet-based Configuration Servers. These URIs SHOULD be partitioned into one set that contains secure schemes (e.g. https://) and another set that contains insecure schemes (e.g., http://). The reason for partitioning the URIs is so all the secure schemes can attempted before any of the insecure schemes (see Section 4.3). When using a secure scheme, the Configuration Server MUST be authenticated using a trust anchor the device possesses. As each Configuration Server may use a different trust anchor, this generalizes to a list of Configuration Server trust anchor certificates.

In order to verify the signature on retrieved configurations, devices supporting ZeroTouch MUST also possess the trust anchor for the Configuration Signer that signed the configuration. Generally, only the manufacturer's trust anchor is needed, as it can then delegate trust for 3rd-party Configuration Signers (see Section 3.4). However, for various reasons, there may be a need for more than one root anchor and therefore this generalizes to a list of Configuration Signer trust anchor certificates.

Devices SHOULD ensure that the certificates for its trust anchors are protected from external modification. It is for this reason that the diagram shows the Configuration Signer and Configuration Server certificates in immutable storage. Similarly, per [Std-802.1AR-2009], the IDevID private key shall be stored confidentially and not available outside the DevID module, hence the diagram shows it is held within secure storage.

4.3. Boot Sequence





Whenever a device boots with its factory default settings, it initiates ZeroTouch with the goal of finding a configuration that will enable it to call home to its deployment-specific NMS.

The process begins with the device using the DHCP protocol to obtain a dynamic assignment for its networking stack. When broadcasting the DISCOVERY request, the device may provide any DHCP options to identify itself or the type of device it is (e.g. IPV4 options 60 or 61).

If the DHCP servers reside on a locally administered network (see Section 1.3), then their OFFER responses MAY include the ZeroTouch Information DHCP option defined in Section 9.1, as well as the legacy DHCP options for TFTP server name, bootfile name, and/or vendor specific information (e.g. IPv4 options 43, 66, 67).

If a DHCP server provides both the ZeroTouch Information and the vendor specific information DHCP options, then the ZeroTouch Information option MUST be processed first. After exhausting all ZeroTouch options without being able to call home, a device MAY then process the information provided by the legacy DHCP options.

The ZeroTouch Information option Section 9.1 provides a set of Configuration Server URIs. If returned by the DHCP server, the device MUST append each URI to the end of one of its two sets of Configuration Server URIs, depending on if the URI's scheme is secure or not. URIs added this way MUST remain distinguishable from those URIs the device was shipped with, for reasons discussed next.

The device then iterates over its two sets of Configuration Server URIs. The device MUST first try all the URIs from the set having secure schemes before trying any of the URIs from the set having insecure schemes. For each URI, until a match is found and successfully loaded, the device attempts to initialize itself from the URI. If the URI uses a secure scheme (e.g., https), the device MUST validate the Configuration Server's certificate using one of its Configuration Server trust anchors. If the device is unable to verify the server's certificate, the device MUST skip that URI. If the device reaches the end of all its URIs without finding a usable match, it SHOULD continue its normal boot sequence using its factory default configuration.

When the device is accessing a Configuration Server URI that it was shipped with (i.e. not discovered while initializing its networking), it MUST do so by appending its GUID to the URI string and using the Accept-Type "application/zerotouch-config", as described in Section 2. For URIs discovered via the ZeroTouch Information option, the device MAY also try the raw URI after trying the permutation using its GUID.

If the Configuration Server returns a configuration, the device MUST first verify it before use. Configuration verification entails both verifying the configuration's signature using the device's list of Configuration Signer trust anchors, and also verifying that the unique identifier within the Configlet matches the device's unique identifier.

Once the configuration is authenticated, the device MUST compare its software image version with the expected version specified within the configuration. If there is a mismatch, the device MUST download the correct image version from the Configuration Server, by appending its GUID to the Configuration Server's URI string and using the Accept-Type "application/zerotouch-bootimage", as described in Section 2. For URIs discovered via the ZeroTouch Information option, the device

MAY also try both the raw URI after trying the permutation using its GUID. Once the image has been downloaded, the device MUST install it and reboot, still with the factory default settings configured, so that ZeroTouch restarts when the device comes back up.

If the device is running the correct software image version, it merges the Configlet's contents into its running configuration. This step effectively modifies the device so that it is no longer having its factory default setting. However, since the Configlet configured the device to "call home," upon entering its normal operating mode, the device immediately begins trying to establish a call home connection, as specified by the Configlet.

If configured to establish a SSH connection, the the device MUST use its IDevID and associated intermediate X.509 certificates as its host key per RFC 6187 [RFC6187]. If configured to establish a TLS connection, the device MUST use its IDevID and associated intermediate X.509 certificates as its server-side certificate for the TLS connection.

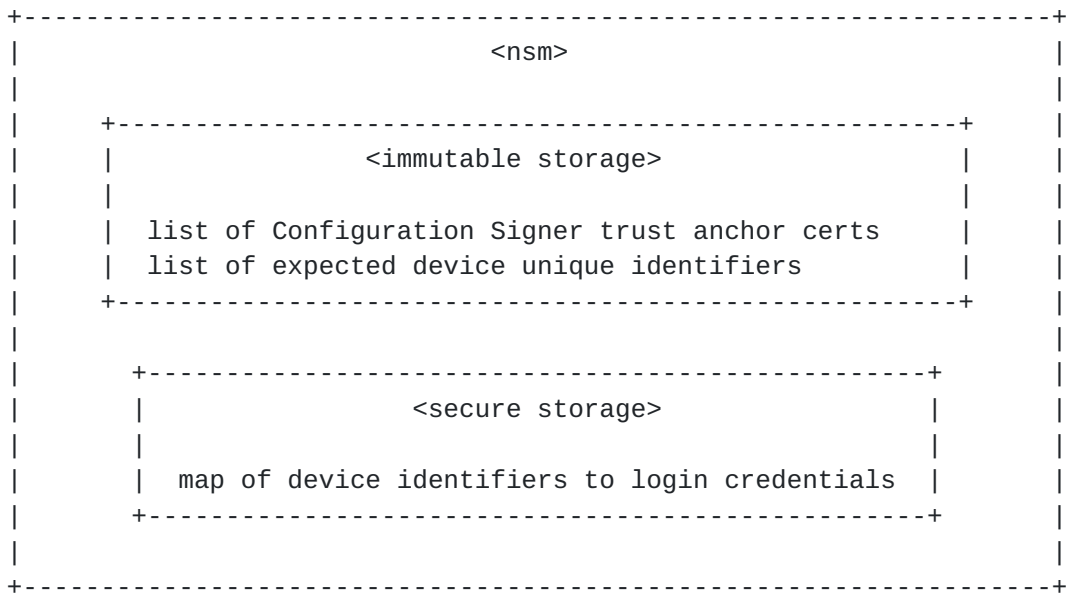
In order to facilitate troubleshooting, the device SHOULD record into a log information relating to its stepping through the ZeroTouch sequence of steps. This draft does not define any specific log messages, for instance, for Syslog or SNMP.

5. Network Management System (NMS)

5.1. Overview

The NMS is the ultimate destination of ZeroTouch for a device. It is the NMS's network address configured in the Configlet. The device will initiate a call home connection to the NMS, using either a SSH or TLS, as configured by the Configlet loaded.

5.2. Precondition



In order to authenticate the device, the NMS MUST possess the X.509 certificate for the trust anchor leading to the device's entity certificate. The NMS uses this certificate to validate the server-certificate the device presents during SSH or TLS transport negotiation. Because an NMS may interoperate with multiple vendors, and a vendor may have more than one trust anchor for signing its devices IDevID certificates, this generalizes into the NMS needing a list of trust anchor certificates. This certificates SHOULD be stored in a way that prevents tampering, which is why they are shown in immutable storage in the diagram.

In order for the NMS to validate that the specific device connecting to it is expected, the MUST have a list of unique device identifiers that it can use to validate the device's IDevID certificate with. The list SHOULD be protected from external modification, which is why it is shown in immutable storage in the diagram. In order for the NMS to know the unique identifiers, device manufacturers will need to provide a mechanism to convey this information to its customers. This draft not specify a format for this information exchange.

In addition to authenticating the device, the NMS must also authenticate itself to the device. How this is done is deployment specific, but generalizes to the NMS needing to have login credentials for each device. These credentials will entail knowing a secret (e.g., password, private key). For this reason the diagram shows the NMS storing a map of device credentials in secure storage.

5.3. Connection Handling

When receiving a NETCONF call home connection from a device, the NSM completes the connection as specified in the SSH [NETCONF-REVERSE-SSH] and TLS [RFC5539bis] drafts.

6. Vendor

6.1. Order Information

In order for a Vendor's customers to preconfigure their NMSs with what devices are expected, as well as to know how to set the "unique-identifier" field within a Configlet when requesting a signing, Vendors need to provide a mechanism for customers to obtain the unique identifier value for the devices they have ordered. For instance, customers could receive emails containing shipping information for their devices.

Additionally, to facilitate workflows where the devices are initially received by a customer-specific warehouse, or moved after having been unboxed, it is ideal for the unique identifier to be easily tracked through labels affixed to the device as well as the box it is packaged in. A device's serial number is commonly treated this way and would be suitable for this purpose, so long as it is directly related to its IDevID identity.

6.2. Ownership Validation

In order for Configuration Signers to validate that a requestor is the true owner of a device (i.e. its IDevID identity), Vendors need to provide a mechanism enabling a near real-time lookup. The interface used to implement this lookup is outside the scope of this document.

7. Configlet

7.1. Overview

A Configlet is an XML file, containing specific YANG-defined configuration, that has been signed by a trusted signer known to the device (e.g., the device's manufacturer).

The Configlet data-model, defined by the YANG module in this document (see Section 7), is just enough to configure a local user account and either reverse-SSH or reverse-TLS. More specifically, this data-model is a subset of what's defined in ietf-system and ietf-netconf-server YANG models. This focused data-model is consistent with the common use-case of having the NMS push a full configuration to a device when it calls home.

The signature on the Configlet is enveloped, meaning that the signature is contained inside the XML file itself. The signature block also contains the X.509 certificate of the Configlet Signer and its chain of trust.

Once a device authenticates the signature on a Configlet and matches the unique identifier (e.g., serial number) within the Configlet, it merges the configuration contained in the Configlet into its running datastore.

7.2. Data Model

```
module: ietf-netconf-zerotouch
   +--rw configlet
      +--rw target-requirements
      |  +--rw unique-identifier    string
      |  +--rw software-version     string
      +--rw configuration
```

The Configlet's data model is no more than a wrapper around a header (i.e. <target-requirements>) and a payload (i.e. <configuration>).

The <target-requirements> element contains information that MUST be validated by the device prior to processing the <configuration> element. Specifically, it contains:

- unique-identifier

  The unique-identifier field is used to ensure that the Configlet is loaded onto the targeted device and no other. This field is also used by the Configuration Signer, when ensuring the requestor is the true owner of the device. The value MUST be the same as the 'subject' field in the device's DevID credential, as specified by section 7.2.8 in IEEE Std 802.1AR-2009.

- software-version

  The software-version field is used to ensure the device is running the right software version prior to loading the

configuration (e.g., 14.1R2.5). If the device finds that it is not running the correct version of software, it can pull the correct version from the Configuration Server.

The <configuration> element contains the configuration that is to be committed to the device's running datastore. This element uses the "anyxml" type, enabling it to contain either vendor-specific or standards-based data models. When using standard models, in order to complete a call home connection, only the following is needed:

- The "authentication" subtree from "ietf-system", defined in draft-ietf-netmod-system.
- If TLS is supported, everything from "ietf-system-tls-auth", defined in draft-ietf-netconf-server-model.
- The "call-home" subtree from "ietf-netconf-server", defined in draft-ietf-netconf-server-model.

7.3. Signature

All Configlets MUST be signed by a Configuration Signer in order to be authentic. Devices MUST reject any Configlet that is either unsigned or having an invalid signature. Configlets are signed using the W3C standard "XML Signature Syntax and Processing" [XMLSIG]. The entire contents of the Configlet MUST be signed. The signature block must also include the Configlet Signer's certificate and any intermediate certificates leading to a Configlet Signer trust anchor. A signed Configlet example is in section Appendix A.1.

7.4. Encryption (optional)

Configlets MAY optionally be encrypted prior to being signed. Encrypting the Configlet provides confidentiality for the Configlet's contents without relying on transport-level security. Configlets are encrypted using the W3C standard "XML Encryption Syntax and Processing" [XMLENC]. The entire contents of the Configlet MUST be encrypted. An encrypted Configlet example is in section Appendix A.2.

7.5. YANG Module

Following is the YANG module for the Configlet:

```
module ietf-netconf-zerotouch {

  namespace "urn:ietf:params:xml:ns:yang:ietf-netconf-zerotouch";
  prefix "zerotouch";
```

```
     organization
      "IETF NETCONF (Network Configuration) Working Group";

     contact
      "WG Web:   <http://tools.ietf.org/wg/netconf/>
       WG List:  <mailto:netconf@ietf.org>

       WG Chair: Mehmet Ersue
                 <mailto:mehmet.ersue@nsn.com>

       WG Chair: Bert Wijnen
                 <mailto:bertietf@bwijnen.net>

       Editor:   Kent Watsen
                 <mailto:kwatsen@juniper.net>";

     description
      "This module contains a collection of YANG definitions for
       configuring NETCONF zerotouch.

       Copyright (c) 2014 IETF Trust and the persons identified as
       authors of the code. All rights reserved.

       Redistribution and use in source and binary forms, with or
       without modification, is permitted pursuant to, and subject
       to the license terms contained in, the Simplified BSD
       License set forth in Section 4.c of the IETF Trust's
       Legal Provisions Relating to IETF Documents
       (http://trustee.ietf.org/license-info).

       This version of this YANG module is part of RFC XXXX; see
       the RFC itself for full legal notices.";
     // RFC Ed.: replace XXXX with actual RFC number and
     // remove this note

     // RFC Ed.: please update the date to the date of publication

     revision "2014-07-01" {
       description
        "Initial version";
       reference
        "RFC XXXX: A YANG Data Model for NETCONF ZeroTouch Configlet";
     }

     container configlet {
       description
        "Top-level container for ZeroTouch configuration objects.";
```

```
      container target-requirements {
        description
          "Specifies requirements for device this is loaded onto";
        leaf unique-identifier {
          type string;
          mandatory true;
          description
            "The device MUST have this unique identifier.  The value
             MUST be the same as the 'subject' field in the device's
             DevID credential, as specified by section 7.2.8 in
             IEEE Std 802.1AR-2009.";
        }
        leaf software-version {
          type string;
          mandatory true;
          description
            "The device MUST must be running this version of software.
             The value for this field is device-specific, but it MUST
             be an exact match (e.g., 14.1R2.5)";
        }
      }
      anyxml configuration {
          mandatory true;
          description
            "The configuration to be committed to the device's running
             datastore.  The configuration MUST be valid for the target
             device.  Device's supporting ZeroTouch SHOULD at least
             support both the following standard data-models:

               ietf-system             // the authentication container
               ietf-system-tls-auth    // everything, if TLS supported
               ietf-netconf-server     // the call-home container

             These three data models contain everything needed to
             support NETCONF call home using either SSH or TLS.";
      }
    }

  }
```

8. Security Considerations

8.1. Immutable storage for trust anchors

Devices SHOULD ensure that all its trust anchor certificates, including those for the Configuration Signer and Configuration Server, are protected from external modification. It is for this reason that the diagram in Section 4.2 shows them in immutable storage.

However, it may be necessary to update these certificates over time (e.g., the vendor wants to delegate trust to a new CA). It is therefore expected that devices MAY update these trust anchors when needed through a verifiable process, such as a software upgrade using signed software images.

8.2. Substitutions

It is generally not possible to substitute a Configlet created for a different device, since devices assert that the Configlet contains their unique identifier (e.g., serial number).

However, it is possible to substitute a Configlet created for a device with a different Configlet created for the same device. Generally, unless imposed by the Configuration Signers, there is no limit to the number of Configlets that may be generated for a given device. This could be resolved, in part, by placing a timestamp into the Configlet and ensuring devices do not load Configlets older than some amount, but this requires the devices have an accurate clock when validating a Configlet and for Configuration Signers to not sign a Configlet when another Configlet is still active.

8.3. Confidentiality

This draft allows devices to use insecure schemes when doing a Configuration Server lookup. This is deemed acceptable because the Configlet is tamper-proof, since it MUST be signed, only confidentiality is lost.

Confidentiality of a Configlet's contents is assured when either the Configlet is encrypted or when the a secure scheme is used when accessing the Configuration Server.

Some confidentiality is lost when an insecure scheme is used to access a Configuration Server, as then the device's unique identifier is in the clear.

Given the fairly regular format for unique identifiers, it is possible that an adversary to guess unique identifiers and access a device's Configlet. Configlets that have been encrypted do not disclose any confidential information.

8.4. Entropy loss over time

Section 7.2.7.2 of the IEEE Std 802.1AR-2009 standard says that IDevID certificate should never expire (i.e. having a notAfter 99991231235959Z). Given the long-lived nature of these certificates, it is paramount to use a strong key length (e.g., 512-bit ECC). Vendors SHOULD deploy Online Certificate State Protocol (OCSP) responders or CRL Distribution Points (CDP) to revoke certificates in case necessary.

8.5. Serial Numbers

This draft mentions using the device's serial number as its unique identifier in its IDevID certificate. This is because serial numbers are ubiquitous and prominently contained in invoices and on labels affixed to devices and their packaging. That said, serial numbers many times encode revealing information, such as the device's model number, manufacture date, and/or sequence number. Knowledge of this information may provide an adversary with details needed to launch an attack. To address this concern, the certificate could contain the hash of the serial number instead, which the NMS could also compute, but doing so is much less intuitive and raises questions if it is just security through obscurity.

9. IANA Considerations

9.1. ZeroTouch Information DHCP Option

TBD, but it essentially returns a list of URIs.

9.2. Media Types for Images and Configurations

TBD, but in accordance with RFC 6838, the draft registers: application/zerotouch-configlet and application/zerotouch-bootimage

10. Acknowledgements

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Appendix A. Examples

A.1. Signed Configlet

This example illustrates a Configlet configuring both a local user account and call home using SSH. This Configlet includes both the Configuration Signer's certificate as well as an Intermediate certificate. Note that '\' characters have been added for formatting reasons.

```
<?xml version="1.0"?>
<configlet xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-zerotouch">

  <target-requirements>
    <unique-identifier>0123456789</unique-identifier>
    <software-version>14.1R3.5</software-version>
  </target-requirements>

  <configuration>

    <!-- from ietf-system.yang -->
    <system xmlns="urn:ietf:params:xml:ns:yang:ietf-system">
      <authentication>
        <user>
          <name>admin</name>
          <ssh-key>
            <name>admin's rsa ssh host-key</name>
            <algorithm>ssh-rsa</algorithm>
            <key-data>AAAAB3NzaC1yc2EAAAADAQABAAABAQDeJMV8zrtsi8CgEsRC
            jCzfve2m6zD3awSBPrh7ICggLQvHVbPL89eHLuecStKL3HrEgXaI/O2Mwj
            E1lG9YxLzeS5p2ngzK61vikUSqfMukeBohFTrDZ8bUtrF+HMLlTRnoCVcC
            WAw1lOr9IDGDAuww6G45gLcHalHMmBtQxKnZdzU9kx/fL3ZS5G76Fy6sA5
            vg7SLqQFPjXXft2CAhin8xwYRZy6r/2N9PMJ2Dnepvq4H2DKqBIe340jWq
            EIuA7LvEJYql4unq4Iog+/+CiumTkmQIWRgIoj4FCzYkO9NvRE6fOSLLf6
            gakWVOZZgQ8929uWjCWlGlqn2mPibp2Go1</key-data>
          </ssh-key>
          <!--<password>$1$salt$hash</password>-->
        </user>
      </authentication>
    </system>

    <!-- from ietf-netconf-server.yang -->
    <netconf-server xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-server">
     <ssh>
      <call-home>
        <applications>
          <application>
            <name>config-mgr</name>
            <description>
               This entry requests the device to periodically
```

```
                connect to the Configuration Manager application
              </description>
              <servers>
                 <server>
                    <address>config-mgr1.example.com</address>
                 </server>
                 <server>
                    <address>config-mgr2.example.com</address>
                 </server>
              </servers>
              <connection-type>
                <periodic>
                  <timeout-mins>5</timeout-mins>
                  <linger-secs>10</linger-secs>
                </periodic>
              </connection-type>
              <reconnect-strategy>
                 <start-with>last-connected</start-with>
                 <interval-secs>10</interval-secs>
                 <count-max>3</count-max>
              </reconnect-strategy>
              <host-keys>
                 <host-key>
                    <name>ssh_host_key_cert</name>
                 </host-key>
                 <host-key>
                    <name>ssh_host_key_cert2</name>
                 </host-key>
              </host-keys>
            </application>
          </applications>
        </call-home>
       </ssh>
      </netconf-server>

    </configuration>
    <Signature xmlns="http://www.w3.org/2000/09/xmldsig#">
      <SignedInfo>
        <CanonicalizationMethod
          Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#"/>
        <SignatureMethod
          Algorithm="http://www.w3.org/2000/09/xmldsig#rsa-sha1"/>
        <Reference>
          <Transforms>
            <Transform
              Algorithm=\
              "http://www.w3.org/2000/09/xmldsig#enveloped-signature"/>
          </Transforms>
```

```
          <DigestMethod
            Algorithm="http://www.w3.org/2000/09/xmldsig#sha1"/>
          <DigestValue>2xlFdlVifb1snGBLJuEZYrLjSUQ=</DigestValue>
        </Reference>
      </SignedInfo>
      <SignatureValue>\
  HUx3S7TZXGJGUhazWGRSB9CBMZ0T+tTrB1fOnTcKi9wU4UOnSw5KMWDvOVwc6ldM
  UIOJIuJigWhSkn+VvWSWz6qy7LTYIywNcxDyghMvmMXfoRXETpL+qCDxribMi4VW
  mVhEw1oe83kJt7W/0DJUE7FFKRUhPjy9EgxpQX/7WdKSK+4f2uYkSpq2UumW3DIU
  LeK9vNRVQBbhmcF3zZWANmwKH5V4WeQimwWE497AeSYWgSImSetADI0NvvXfBZjx
  JqzFEaYLNz8IB0ZVY+w14s1RZbN7YmxhN1R3q52wWvHjR2SylR/Z5BpIhYoDeKoD
  HMQMf3HZL06Hm5S8r8rgGg==</SignatureValue>
      <KeyInfo>
        <X509Data>
          <X509Certificate>\
  MIIFKjCCBBKgAwIBAgIBAjANBgkqhkiG9w0BAQsFADAwMRMwEQYDVQQKFApUUE1f
  VmVuZG9yMRkwFwYDVQQDFBBKdW5pcGVyX1hYWFhYX0NBMB4XDTEzMTAyMDE2MjIx
  MFoXDTE0MTAyMDE2MjIxMFowKzETMBEGA1UEChQKVFBNX1ZlbmRvcjEUMBIGA1UE
  AxQLY2hpcF8wMDAwMDEwggEiMA0GCSqGSIb3DQEBAQUAA4IBDwAwggEKAoIBAQDf
  4hyWqFsf801sZYJQBJ0PB4cHmlnPNOs9pv3QCCB1PzlYhfcDOygVmqhzZjPY+t7q
  ZTjPs/E8n5X4dd0DkR80uc4MWmzc40Pz2HAW6GQ2mo+eUYzXUqQFbi3EkqrzddZk
  gRi6vuadMkAcJH8ugYR+cbw/LlpXhIy2A5fUh4JP7Y9l1wABTbK8eGhF9cvGxBYR
  +KqZJycoV6aaIvD/0NO1CNSaGeAJXXxXWoRF5E6HVKsolTHPPdi+40BmYrCuuWy6
  1ybCIP5uZZ7Oza4j0n/fPb6SEqEa0I1zUEWlFQMZYsBClNY5TzWHNgQ5dPJO2qgx
  PONwnLIsx46DlAzlpFpXAgMBAAGjggJSMIICTjAMBgNVHRMBAf8EAjAAMIGTBgNV
  HSABAf8EgYgwgYUwgYIGC2CGSAGG+EUBBy8BMHMwOQYIKwYBBQUHAgEWLWh0dHA6
  Ly93d3cudmVyaXNpZ24uY29tL3JlcG9zaXRvcnkvaW5kZXguaHRtbDA2BggrBgEF
  BQcCAjAqGihUQ1BBIFRydXN0ZWQgUGxhdGZvcm0gTW9kdWxlIEVuZG9yc2VtZW50
  MIHXBgNVHSMEgc8wgcyAFCHd7bYICEQX3QxR30ixhppG7bjmoYGwpIGtMIGqMQsw
  CQYDVQQGEwJVUzETMBEGA1UECBMKQ2FsaWZvcm5pYTESMBAGA1UEBxMJU3Vubnl2
  YWxlMRkwFwYDVQQKFBBKdW5pcGVyX05ldHdvcmtzMR0wGwYDVQQLFBRDZXJ0aWZp
  Y2F0ZV9Jc3N1YW5jZTEZMBcGA1UEAxQQVFBNX1RydXN0X0FuY2hvcjEdMBsGCSqG
  SIb3DQEJARYOY2FAanVuaXBlci5jb22CAQEwcQYDVR0fBGowaDBmoC6gLIYqaHR0
  cDovL2NybC5qdW5pcGVyLm5ldD9jYT1KdW5pcGVyX1hYWFhYX0NBojSkMjAwMRMw
  EQYDVQQKFApUUE1fVmVuZG9yMRkwFwYDVQQDFBBKdW5pcGVyX1hYWFhYX0NBMFsG
  A1UdEQEB/wRRME+kTTBLMQswCQYDVQQGEwJVSzEYMBYGA1UEChMPTXkgT3JnYW5p
  emF0aW9uMRAwDgYDVQQLEwdNeSBVbml0MRAwDgYDVQQDEwdNeSBOYW1lMA0GCSqG
  SIb3DQEBCwUAA4IBAQCsVFVA90O8E4p/8ohBYQRezVaWidTHCTM1sdAoeljlrsFX
  xqwcQEGVT3BpzwN8w2r+iKOKLQkWv64os0KKL0RIIjmCmJ2RukqH/R0M8Air4+Im
  iWI3xV+HzVRsJIrCRT2tzxbchU/i/LQiwhteUEZ9sZbHKyLQe9x9HgByM05ifOGh
  z2dcb7AWNlo7nJtRBmx0v9iim2kktqGMuXgBzlnMMabqHMb4L+vjww2Wn5nNYbr/
  oXq4fa01MGQyvRPAEOwL3ZxcaqKHvmTn9coBLhpP3nQIEV+V+PngQjtBmwdkjIj5
  feDp86jGN6348H+z9CzXUSbyOn6utIxN0SvVESxx</X509Certificate>
          <X509Certificate>\
  MIIExTCCA62gAwIBAgIBATANBgkqhkiG9w0BAQsFADCBqjELMAkGA1UEBhMCVVMx
  EzARBgNVBAgTCkNhbGlmb3JuaWExEjAQBgNVBAcTCVN1bm55dmFsZTEZMBcGA1UE
  ChQQSnVuaXBlcl9OZXR3b3JrczEdMBsGA1UECxQUQ2VydGlmaWNhdGVfSXNzdWFu
  Y2UxGTAXBgNVBAMUEFRQTV9UcnVzdF9BbmNob3IxHTAbBgkqhkiG9w0BCQEWDmNh
```

```
QGp1bmlwZXIuY29tMB4XDTEzMTAyMDE2MjIwOVoXDTE0MTAyMDE2MjIwOVowMDET
MBEGA1UEChQKVFBNX1ZlbmRvcjEZMBcGA1UEAxQQSnVuaXBlcl9YWFhYWF9DQTCC
ASIwDQYJKoZIhvcNAQEBBQADggEPADCCAQoCggEBAK+D34JQ/tsWv5SZ5L2TF7u7
xo7eZEpz/BmnXhxa6keBx5gmjkBXgfSMov7ZJaZfzXkCL01YDDCDQyXBLkh/n2bL
3K0AkEUJPTJgSTTQbPtLkVJgWWAwYASu3/L88c9JH33tvPNQusL0qW683Pd3iVV5
VFOe7c2ZZ0aUtw/FBexjOwPmkQdivb78mfNwyJYkgy0dq0z5GaIIZNna2de1N/Jk
mStZEB6+QJfn0qRsaJbA3TS5JQ13ZBSOqcvtjOIDingjHCXGWEULTeF1UVExNXEG
fsHY2CtQaP/r8hT/8TjPB4mJpbuG1P/BpIAXtBC+hqggwAnNpVfcAxReozzoFCcC
AwEAAaOCAW0wggFpMBIGA1UdEwEB/wQIMAYBAf8CAQAwHQYDVR0OBBYEFCHd7bYI
CEQX3QxR30ixhppG7bjmMIHfBgNVHSMEgdcwgdSAFH+nvIT5PZV62rnjGbqzwT2R
K1FOoYGwpIGtMIGqMQswCQYDVQQGEwJVUzETMBEGA1UECBMKQ2FsaWZvcm5pYTES
MBAGA1UEBxMJU3Vubnl2YWxlMRkwFwYDVQQKFBBKdW5pcGVyX05ldHdvcmtzMR0w
GwYDVQQLFBRDZXJ0aWZpY2F0ZV9Jc3N1YW5jZTEZMBcGA1UEAxQQVFBNX1RydXN0
X0FuY2hvcjEdMBsGCSqGSIb3DQEJARYOY2FAanVuaXBlci5jb22CCQCVivZlfsyT
TzAOBgNVHQ8BAf8EBAMCAgQwQgYDVR0fBDswOTA3oDWgM4YxaHR0cDovL2NybC5q
dW5pcGVyLm5ldD9jYT1KdW5pcGVyX1RydXN0X0FuY2hvcl9DQTANBgkqhkiG9w0B
AQsFAAOCAQEAXw4/3c9yC4TiYTxHmEXoqYgw2+xyEtJIEs3Kv7MSbF/cJwXz4lci
8Fy3ZiKgq9gj9vloWLT5V9ri1HCgalD8D56iKtQCOvY7TJ64qChAA8q7/WNC3dbJ
s9Op6+nSpolfG8YNHfBroCSfNOVCteJ+pU26p3cC1150Pr+/yZZHnsMhNLYuLCvq
29uvnPDBC4MMVfcMbasPpsxL7Ue4PJsjnLquGLZ33MgNGP1TdefvYCFLF2ZEIbvi
KEGLOTXMrXsbUbQLZAdlq6kLCm7A3u6gwTMg+NydCziVsARq+ZKJS0n3vDoAIJxl
BfXhJE4VOjAEQ8w+Sftu1lu6rJZr3ctSLg==</X509Certificate>
      </X509Data>
    </KeyInfo>
  </Signature>
</configlet>
```

A.2. Signed Encypted Configlet

This example is the same as to previous example (section Appendix A.1) except that the Configlet was encrypted using the device's public key prior to being signed using the Configuration Server's private key. Note that '\' characters have been added for formatting reasons.

```
// This example is currently missing
```

Appendix B. Change Log

B.1. ID to 00

Complete re-write. Switched from using signed DNS records using DNSSEC to using signed YANG-defined XML files using XML Signature. This update took into a lot a feedback from both operators and vendors.

B.2. 00 to 01

Major structural update; the essence is the same. Most every section was rewritten to some degree.

Added a Use Cases section

Added diagrams for "Actors and Roles" and "NMS Precondition" sections, and greatly improved the "Device Boot Sequence" diagram

Removed support for physical presence or any ability for Configlets to not be signed.

Defined the ZeroTouch Information DHCP option

Added an ability for devices to also download images from Configuration Servers

Added an ability for Configlets to be encrypted

Now Configuration Servers only have to support HTTP/S - no other schemes possible

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